DOCUMENT RESUME

ED 414 811 HE 030 704

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TITLE	Policy Perspectives. Exemplars. Rensselaer Polytechnic Institute.
INSTITUTION	Pew Higher Education Roundtable, Philadelphia, PA; Knight Collaborative, Akron, OH.; Pennsylvania Univ., Philadelphia. Inst. for Research on Higher Education.
SPONS AGENCY	Pew Charitable Trusts, Philadelphia, PA.; John S. and James L. Knight Foundation, Miami, FL.
PUB DATE	1997-08-00
NOTE	9p.; For related documents, see HE 030 702-703. Published in conjunction with "Policy Perspectives."
PUB TYPE	Reports - Descriptive (141)
EDRS PRICE	EDRS Price MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Administrative Change; *College Curriculum; College Faculty; College Instruction; College Students; *Computer Assisted Instruction; Curriculum Design; *Curriculum Development; Educational Attitudes; Educational Change; Engineering Education; Excellence in Education; Higher Education; Mathematics Education; Program Descriptions; *Research Universities; Science Education; *Student Centered Curriculum; Technology Transfer
IDENTIFIERS	*Rensselaer Polytechnic Institute NY

ABSTRACT

This report describes efforts by Rensselaer Polytechnic Institute (New York) to reinvent teaching and learning through the development of a comprehensive curriculum to make learning more student-centered, and to utilize innovative technology in the classroom by replacing the lecture-lab-recitation format with smaller, interactive studio courses. A two-staged restructuring process was initiated to: (1) realize academic excellence through interactive learning, and (2) to preserve financial equilibrium without passing costs on to students. Building on efforts that had already led to the introduction of computer-enhanced calculus into the curriculum, Rensselaer introduced active learning in mathematics, science, and engineering in the form of studio courses with limited enrollments and project-based approaches to instruction. Lecture halls were transformed into "theaters-in-the-round," where students sit at multimedia-based computer workstations and interact with their professors, who teach and lead discussions from the center of the circle. Professors are able to monitor students' work on their own networked workstation, and students feel the need to come to class prepared to demonstrate what they have learned. Comments from students, faculty, and administrators on the new approach to teaching and learning at Rensselaer are included. (MDM)

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ED 414 811

PERSPECTIVES
August 1997

Exemplars Exemplars

Rensselaer Polytechnic Institute

The Problem: *Reverse shortfalls in student learning and poor attendance in large lecture courses, and reduce a structural budget deficit of $25 million.*

The Solution: *Reinvent teaching and learning through a comprehensive curriculum renewal to make the educational experience more student-centered and make innovative use of technology in the classroom, replacing the lecture-lab-recitation format with smaller, interactive studio courses.*

Rensselaer Polytechnic Institute, an institution renowned for its science and engineering programs, faced a problem common to large research universities: its introductory science and math lectures, some with class enrollments of hundreds of students, simply did not stimulate interest. Faculty realized that the traditional format for instruction in introductory-level science courses—lecture, lab, and recitation sessions—was neither conducive to learning nor cost-effective. "Attention was poor, and attendance was poorer," says Professor Jack Wilson, Rensselaer's dean of undergraduate education. Student test performance demonstrated this point; most simply were not learning the fundamental principles of science or math at a level that would provide adequate tools for subsequent inquiry and analysis.

By 1993, Rensselaer had arrived at a two-stage restructuring process with a dual goal: to realize academic excellence through a

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new commitment to interactive learning—a movement away from dry lectures in introductory courses to engaging, smaller classes in which students take primary responsibility for learning—while preserving financial equilibrium. As the 1990s began, Rensselaer faced a structural deficit in excess of $25 million. In order to pursue reform in the delivery of undergraduate education without passing the costs onto students, it had to undertake administrative restructuring to create efficiencies throughout the institution and reallocate dollars in key areas: student financial aid, physical plant and infrastructure, endowment, academic renewal, and competitive salaries for senior faculty.

Although one goal was to cut costs and improve efficiency, the primary impetus for reform was an unprecedented opportunity to reinvent the educational experience through technology. In the 1980s, faculty had brought to life the theories of first-year calculus courses by introducing graphical computer software into the classroom, and the mathematics department was quick to introduce computer-enhanced calculus into its standard curriculum. A sense of discontent among a core of faculty in math and science departments—linked with general concerns about retention and Rensselaer 's market position as a private institution in competition with lower-cost publics—helped build the case for a different mode of teaching and learning. "Spurred in part by a Pew Campus Roundtable," says Rensselaer's dean of faculty, Gary Judd, "we came to realize that we were in the business of knowledge. As such, we were in competition not just with other higher education institutions but with other information providers who would feel less bound to the traditions of the academy than ourselves."

The initial interactive learning environments soon evolved across the curriculum into studio courses, which Rensselaer has become a pioneer in advancing. Already implemented for introductory physics, chemistry, math, and science and engineering, studio courses replace the large lecture-lab-recitation model with interactive learning classes of up to 60 students. This student-centered and

project-based approach to instruction stresses teamwork and problem-solving, with the instructor serving as a resource and catalyst to learning, not as a "talking head" behind a podium. Not only are the courses more lively and better attended, after an initial investment in hardware and software, they are less costly to provide, already realizing savings of $10,000 to $150,000 per course.

Much of the success (and start-up costs) of studio courses is due to a complete redesign of the classroom at Rensselaer—physical changes that give visual witness to this new approach to learning. Rows of desks have disappeared; instead, many classrooms have been transformed into "theaters-in-the-round," where students sit at multimedia-based workstations on specially designed worktables that form concentric ovals. Professors teach and lead discussions from the center of this rough circle; on swivel chairs, students turn to face the professor for brief lectures and return to their workstations when using networked audio, video, graphics, text, and animation capabilities to apply concepts in the lesson.

Professor Wilson describes a typical physics studio, in which instructors move from one mode of teaching to another—uniting functions of the lecture, lab, and recitation in one setting. "During our acceleration-due-to-gravity session," he says, "we videotaped a student throwing a ball. We digitized the video directly into the computer and made it available to every student workstation over the network. Students then analyzed the motion using the on-line scientific tools. Next, they created a spreadsheet illustrating the ball's position-versus-time data, and then plotted their results on computerized graphs. All in one two-hour block." This seamless approach to instruction has a big advantage over the traditional lecture-lab-recitation model, as Davienne Monbleau, a sophomore physics major who also serves as a TA for a physics studio course, explains. "In a lecture course, the elements aren't always connected. What you learned on Monday in a lecture isn't always the topic of discussion in your recitation on Friday. In studios, all of the concepts are connected

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Exemplars

in one session. You're always practicing and reviewing what you've just learned."

From a vantage point at the center of the classroom, professors are able to view all of the students' screens and monitor their progress as they perform virtual experiments, and both professors and TAs can quickly respond to students' questions when problems arise. "In other classes, you don't find out that they 'don't get it' until the test, when it's too late," says Professor Joseph Ecker. "Here, I find out right away." This new format has also improved the relationship between professor and student, contradicting a widely held prejudice against technology instruction. As Professor Gary Adams explains, "Now I actually have more interaction with my students. It's really the difference between knowing the student's name and knowing the student."

And while professor-student interaction has increased, the responsibility for learning has clearly shifted from instructor to student. "There's no step-by-step spoon feeding," says Davienne. "Because you're demonstrating what you've learned, it's more important to come to class prepared. We have more responsibility for what we know, and we're treated more like adults. We learn how to think—how to approach and solve a problem. Studios are also geared toward learning how to work with others, but not in the typical way in large groups, where some students rely on others to get by. We communicate and help each other." In addition to benefiting her scholastically, Davienne believes that her experience will ultimately transfer from the classroom to the workplace. "In today's office, you have to be prepared to work with people in teams, to think critically, and know how to approach problems. Studio courses help to teach those important skills."

Although studio courses reduce the number of contact hours for each re-engineered course, faculty reinvest the saved time by engaging in curriculum reform, research and scholarship, and professional development. In fact, a new culture has evolved among faculty

at Rensselaer, one of experimentation and innovation, and they see themselves as agents of change across the institution. Many Rensselaer faculty are actually developing the instructional technology being used in studio classrooms. For example, CUPLE, the software package for physics that students are using to perform virtual experiments, was created by Professor Wilson. To assist faculty in their efforts, Rensselaer offers hands-on technology training on campus at the International Center for Multimedia Education.

Still in the initial years of implementation, acceptance by some of this new approach to learning has been admittedly slow. "Sure, there are cynics," says Professor Wilson. "But once they're shown something new that saves money and works, they come right on board." The results of recent evaluations only fortify the argument. "Our preliminary data show that students in the new classes are doing as well or better than in the traditional classes," explains Professor Wilson. "Students are also learning faster and more effectively; fewer people are failing." And the rates of attendance in studio classes is an astonishing 90 to 100 percent, compared with only 60 to 70 percent for traditional lecture courses. Wilson also describes how Rensselaer's re-engineering process promotes cost efficiency. "There's a myth that it's too expensive to re-engineer courses. But our studies show that by redesigning our process—instead of just trying to fit in technology—we are achieving significant productivity increases. We're serving the same number of students at a lower cost—and serving them more effectively—with more efficient use of our faculty resources. Now that's a breakthrough!"

Institutional Statistics:

Private, four-year institution in Troy, New York

4,400 undergraduate and **2,000** graduate students

380 full-time faculty, **40** part-time faculty

Milestones on the Path to Reform:

- Curriculum renewal began in 1988, when Rensselaer faculty started incorporating technology into introductory science courses, creating the precursor of the institution's "studio course" approach.

- In the late 1980s, a special interdisciplinary program for first-year students was introduced, composed of several courses in the School of Humanities and Social Sciences that were multidisciplinary, team-taught, and committed to interactive learning.

- The Center for Innovation in Undergraduate education was created to oversee curriculum redesign in 1989.

- The calculus initiative prompted faculty to consider new approaches to learning in conjunction with the Anderson Center for Innovation in Undergraduate Education, an incubator for curriculum renewal, founded in 1989.

- As interactive learning gained momentum, the series of stand-alone experiments became a focused, Institute-wide initiative. Through a strategic planning process in 1990-91, the Panel on Strategic Initiatives declared that interactive learning should be Rensselaer's top priority.

- By 1993, a two-stage restructuring process was identified: the commitment to interactive learning, and the achievement of savings through administrative restructuring to reduce the structural deficit of $25 million.

- The first studio course was implemented in 1993, and Rensselaer began phasing-in these new courses in introductory physics, math, chemistry, and science and engineering over the next three years.

- In 1994, Rensselaer engaged in a Pew Campus Roundtable, which helped to refine its mission and stress the innovative use of technology, as a result of the Roundtable discussions, a goal of $8.4 million in annual savings was targeted through administrative restructuring and the introduction of studio courses.

- "Strategic Initiatives" was established through gifts and endowment to fund faculty proposals to develop renewal projects. From 1992 to 1996, $8 million was allocated for faculty proposals.

- By early 1995, the Curriculum Renewal Implementation Team began revising the curriculum, reducing the number of courses students take while increasing the depth of course offerings. The new course menu—called the 4x4 Curriculum—took its name from the introduction of a standard semester of four, four-credit courses, replacing the former typical semester of five or six three-credit courses.

- In 1995, Rensselaer received a National Science Foundation grant of $4 million to lead Project Links by developing interactive multimedia materials for courses in mathematics, electronics, manufacturing, and management.

- In 1996, the newly renovated Walker Laboratory was reopened, from room layout, to furniture, to computer equipment, Walker classrooms were designed to facilitate student teamwork and faculty mentoring.

- Plans are currently being developed to implement interactive learning across the curriculum, stressing teamwork, leadership, the role of the faculty as mentors, and deploying the studio model as appropriate.

- Two courses, Introduction to Engineering Design and Laboratory Introduction to Embedded Control, have begun to serve as paradigms of interactive learning that takes place in a project-based, team-intensive environment. The nurturing of instructional innovation pays off with courses that augment the studio model.

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Exemplars is supported by The Pew Charitable Trusts and the John S. and James L. Knight Foundation and is a publication of the Pew Higher Education Roundtable and the Knight Collaborative.

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Rensselaer Polytechnic Institute is one of three recipients of the 1996 Pew Leadership Award for the Renewal of Undergraduate Education.

The institutional profile for this ***Exemplars*** was researched and written by Maria Iannozzi.

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